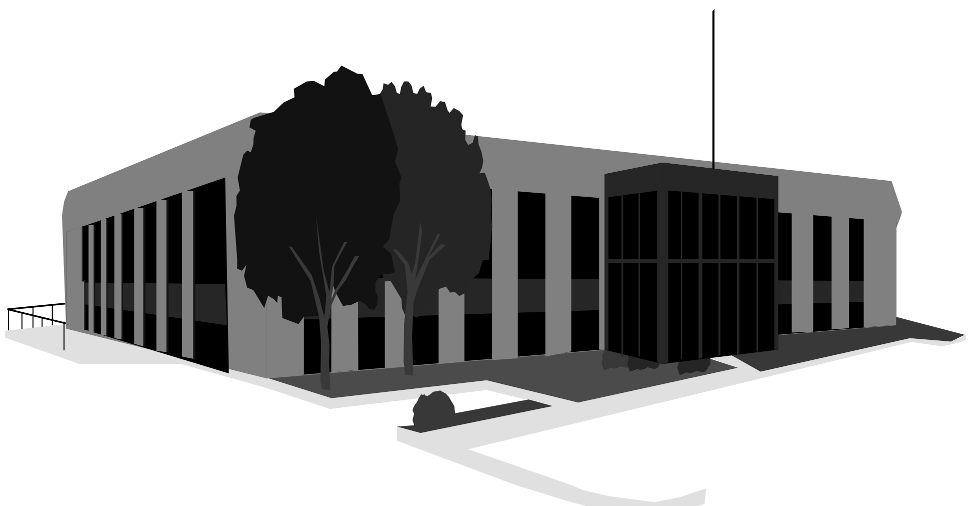
INDOOR AIR QUALITY ASSESSMENT

Charles W. Morey Elementary School
114 Pine Street
Lowell, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

February, 2001

Background/Introduction

At the request of the Lowell Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality and health concerns at the Morey Elementary School in Lowell, Massachusetts. On October 25, 2000 a visit was made to this school by Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) Program, to conduct an indoor air quality assessment.

The school is a three-story red brick building constructed in 1881. An addition was constructed in 1968 and two modular classrooms were added in 1997. The school utilizes an annex building adjacent to the school as a library. The school consists of general classrooms, auditorium/gymnasium, music room and office space. Most classrooms are equipped with openable windows.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 500 and a staff of approximately 60. The tests were taken during normal operating hours at the school. Test results appear in Tables 1-6.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm in twenty-one of thirty-three areas surveyed indicating an overall ventilation problem in the school. It should be noted that many rooms had open windows/doors during the assessment, which can greatly contribute to reduced carbon dioxide levels. Of note were classrooms 1, 4, 8, and the modular classrooms, all of which had levels of carbon dioxide in excess of 2,000 ppm, which indicates little or no air exchange.

Fresh air in most classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 2) and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating/cooling coil, and is then provided to classrooms from the univent by motorized fans through fresh air diffusers located at the top of the unit (see Figure 1). Univents were deactivated in a number of classrooms. Without univents operating, the ventilation system does not function as designed, preventing fresh outside air from being distributed to occupied areas. Obstructions to airflow, such as books, papers and posters on top of univents, and bookcases, tables and desks in front of univent returns were also seen in a number of classrooms (see Picture 3). To function as designed, univent air diffusers and returns must remain free of obstructions. It is important that these units be activated and allowed to operate during school hours.

The mechanical exhaust ventilation system for classrooms in the original building consists of ducted, grated wall vents; many of which were obstructed by furniture, storage carts, shelves, and other items (see Pictures 4 & 5). Exhaust vents were not drawing air in a number of classrooms, which can indicate that exhaust ventilation was turned off, or that rooftop motors were not functioning. Hallway doors were found open in a number of classrooms. The location of exhaust vents can limit exhaust efficiency when the classroom door is open (see Picture 6). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Exhaust ventilation for the 1968 addition is provided by unit exhaust ventilators, some of which were not operating. With decreased function of exhaust vents, normally occurring environmental pollutants can build up and lead to indoor air quality and comfort complaints.

Ventilation for modular classrooms, core rooms and common areas is provided by ducted air handling units (AHUs) located on the roof or in mechanical rooms (see Picture 7). Each modular classroom has its own AHU. Fresh air is distributed via ductwork connected to ceiling-mounted air diffusers. The amount of fresh air drawn into the units is controlled by moveable louvers connected to an activator motor that adjusts to alter fresh air intake to maintain temperature. Return vents draw air back to the units through wall or ceiling-mounted grilles. Thermostats control heating, ventilating and air conditioning (HVAC) systems (see Picture 8). In modular classrooms, thermostats have settings of “on” and “automatic”. Thermostats were set to the “automatic” setting in all of the modular rooms surveyed during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature measurements ranged from 68^{o} F to 77^{o} F, which were close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. A number of occupants complained of uneven heating and cooling. Heat complaints were specifically reported in the computer room, which contained 25 (+) computers and a number of printers. The computer room is located in a general classroom, which is not equipped with air conditioning. Computer equipment and printers can generate waste heat while they operate. Without removal by the exhaust ventilation system, excess heat can build up and lead to poor air quality and comfort complaints. It is difficult to control temperature and maintain comfort without the HVAC equipment operating as designed. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building ranged from 27 to 44 percent, which was below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water damaged ceiling tiles, windowsills and wall plaster were observed in many areas (see Picture 9). Water-damaged ceiling tiles and porous building materials (e.g. wallboard) can provide a source of mold and mildew and should be replaced after a water leak is discovered. Classroom 5 and the hallway ceiling outside of this room contained tiles with possible mold growth (see Picture 10). School maintenance personnel reported that the city public works department had recently repaired a leak in this area, which was confirmed by the presence of a sealant compound noted above the ceiling tiles (see Picture 11). Building occupants reported that the repair was successful.

Pooling water was noted on the roof in close proximity to a univent fresh air intake (see Picture 12). The collection of water and the subsequent freezing and thawing during winter months can lead to roof leaks and water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth and subsequently result in unpleasant odors and providing a breeding ground for mosquitoes. The close proximity of water pooling to the fresh air intake creates a potential for the entrainment of moisture into the HVAC system when activated, which can lead to water damage as well as possible mold growth within the unit.

Caulking around windowpanes was crumbling, missing or otherwise damaged in many areas (see Picture 13). Repairs of window leaks are necessary to prevent further water penetration. Repeated water damage can result in mold colonization of window frames, curtains and items stored on or near windowsills.

Water intrusion was evident by the presence of efflorescence (i.e. mineral deposits) and water-damaged plaster around window frames (see Picture 9). Efflorescence is a characteristic sign of water penetration through building materials (e.g.

brick, mortar, plaster) but it is not mold growth. As moisture penetrates and works its way through porous materials, water-soluble compounds dissolve, creating a solution. As this mixture moves to the surface of the material, the water evaporates, leaving behind white, powdery mineral deposits commonly referred to as efflorescence. Water-damaged wall plaster, if wetted repeatedly, can be a medium for mold growth. Repairs of window leaks are necessary to prevent further water penetration. Repeated water damage can result in mold colonization of window frames, curtains and items stored on windowsills.

Other Concerns

Several conditions that can potentially affect indoor air quality were also identified. The custodial office is located in the boiler room. During the assessment this door was observed open (see Picture 14) and oil fumes and boiler room odors were noted in the main hallway outside this area. The open door to the boiler room can serve as a means of egress for odors, fumes, dusts and vapors from the boiler room into adjacent areas.

Several areas contained exposed fiberglass insulation (see Tables/Picture 15). Accumulated chalk dust was noted in several classrooms (see Picture 16). Also of note was the amount of materials stored in some areas. In many classrooms and common areas items were seen piled on windowsills, tabletops, counters, bookcases and desks (see Picture 17). The large amount of items stored provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These stored items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Chalk dust, household dust and fiberglass insulation can become easily aerosolized and serve as a source of eye and respiratory irritation. In addition, fiberglass insulation material can also serve as a source of skin irritation to sensitive individuals.

Cleaning products were found in a number of classrooms. A spray can of insecticide was noted in the library (see Picture 18). Cleaning products and insecticides contain chemicals that can be irritating to the eyes, nose and throat and should be kept out of reach of students. In addition, applicators of pesticides should be in full compliance with federal and state rules and regulations that govern pesticide use including posting and notification requirements (333 CMR 13.10). Under no circumstances should this material be applied by untrained personnel. This product should not be applied prior to or during school hours. If application must be done during the school week, this material should be applied shortly after the school day ends, in order to give the applied areas ample time to dry. Under current Massachusetts law that will go into effect November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). A copy of the IPM guide is attached as Appendix A.

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

A restroom exists off the main hallway across from the main office, which is also used for storage. This restroom is equipped with floor drains (see Picture 19) used for drainage. Drains are designed with traps in order to prevent sewer odors/gases from penetrating into occupied spaces from the sewer system. When water enters a drain, the trap fills and forms a watertight seal. Without periodic input of water (e.g. every other day), traps can dry and compromise the integrity of the watertight seal. If traps dry out, sewer odors/gases can travel up the drain into occupied areas. The passive door vent for the boys' restroom was sealed with plywood (see Picture 20). Restroom doors are normally equipped with passive door vents, which allow airflow into restrooms to aid in the removal of odors and water vapor.

Evidence of bird roosting was noted in a hole in the exterior wall of the annex building (see Picture 21). Accumulations of bird wastes were noted in and around the opening on the exterior of the building. No evidence of bird infestation was observed in the occupied portion of the annex building, however, the building does contain an attic, which BEHA staff were unable to observe. Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system.

Conclusions/Recommendations

The symptoms reported at the Morey Elementary School (e.g. temperature complaints, eye/throat irritation) are consistent with might be expected based upon building conditions observed during the assessment. The deactivation of ventilation systems in combination with the build-up of normally occurring environmental contaminants (e.g. household dust, carbon dioxide, office equipment) has lead to comfort complaints associated with poor indoor air quality. In view of the findings at the time of the inspection, the following recommendations are made:

1) To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.

2) Examine each AHU and univent and for proper function. Survey equipment to ascertain if an adequate air supply exists for each area serviced. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the maintenance and calibration of HVAC equipment and univent fresh air control dampers school-wide.

3) Change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed. Consider increasing the dust-spot efficiency of HVAC filters.

4) Inspect exhaust motors and belts for proper function. Repair and/or replace as necessary.

5) Close classroom doors to maximize exhaust ventilation.

6) Remove all blockages from univents and exhaust vents to ensure adequate airflow.

7) Once both the fresh air supply and the exhaust ventilation are functioning properly, the system should be balanced by an HVAC engineer.

8) For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

9) Replace any water-damaged ceiling tiles and building materials. Examine the areas above and around these areas for mold growth. Repair water leaks and disinfect areas of water leakage with an appropriate antimicrobial if necessary.

10) Inspect roof for proper drainage. Consider consulting a building engineer about possible options to eliminate water pooling on roof.

11) Repair/replace loose, missing or damaged window caulking building-wide to prevent water penetration through window frames.

12) Store cleaning products and chemicals properly and keep out of reach of students.

13) Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.

14) Encapsulate exposed pipe insulation to avoid the aerosolization of fiberglass materials.

15) Seal drains in restroom or pour water down regularly to prevent sewer gas back up.

16) Use IPM to remove pests from the building. A copy of the IPM recommendations is included with this report as Appendix A (MDFA, 1996). Activities that can be used to eliminate pest infestation may include the following activities.

    i) Consultation with a licensed pesticide applicator on the most appropriate method to end infestation.

    ii) Reduction/elimination of pathways/food sources that are attracting pests.

    iii) Reduction of harborages (plants/cardboard boxes) where pests may reside.

17) Determine extent of bird roosting in annex building depicted in Picture 14. If extensive, the area should be professionally cleaned of all bird wastes and

disinfected. Seal breach in the exterior of the building to prevent reoccupation by birds.

References

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

333 CMR 13.10. Code of Massachusetts Regulations. Pesticide Board. Standards for Application. Volume 17. Boston, MA.

Mass Act, 2000. An Act Protecting Children and Families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E

MDFA. 1996. Integrated Pest Management Kit for Building Managers. Massachusetts Department of Food and Agriculture, Pesticide Bureau, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Picture 1

Classroom Univent: Note Return Vent along Front of Unit is Obstructed

Picture 2

Univent Fresh Air Intake

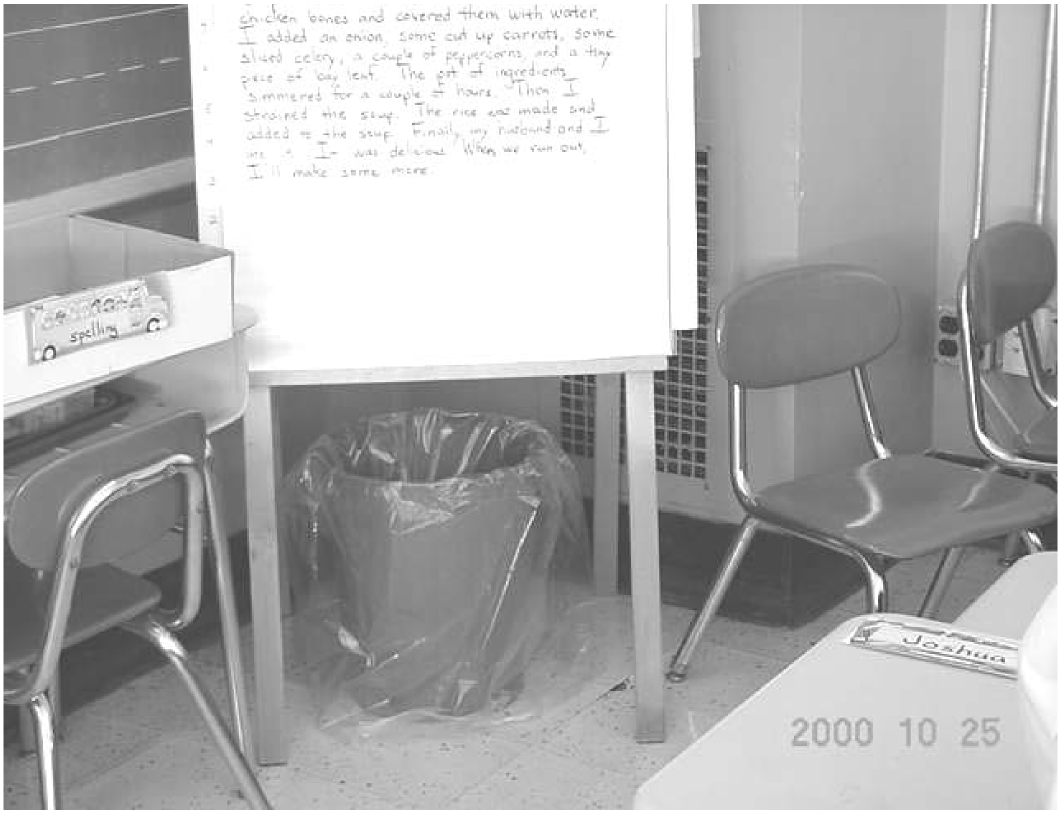
Picture 3

Classroom Univent Obstructed by Bookshelves and other items

Picture 4

Classroom Exhaust Vent

Picture 5



Classroom Exhaust Vent Obstructed by Various Items

Picture 6

Proximity of Exhaust Vents to Hallway Doors

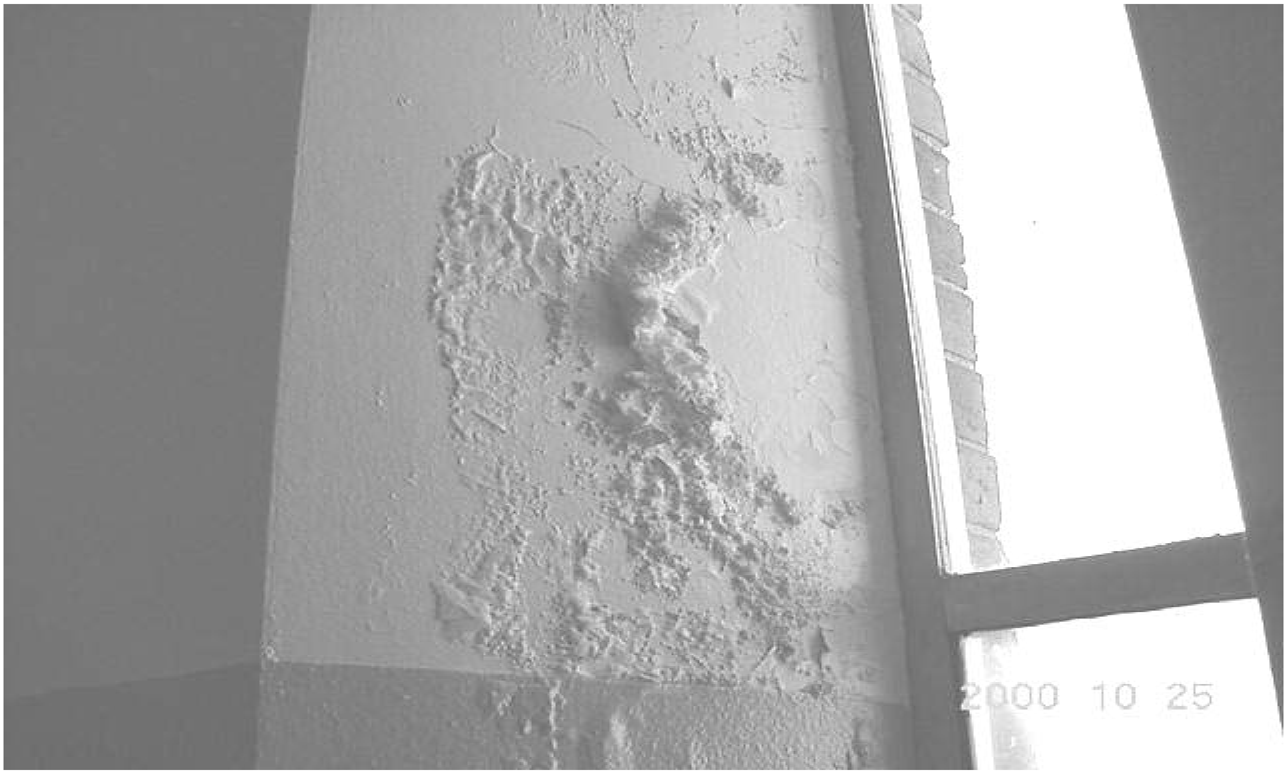
Picture 7

Rooftop HVAC Units for Modular Classrooms

Picture 8

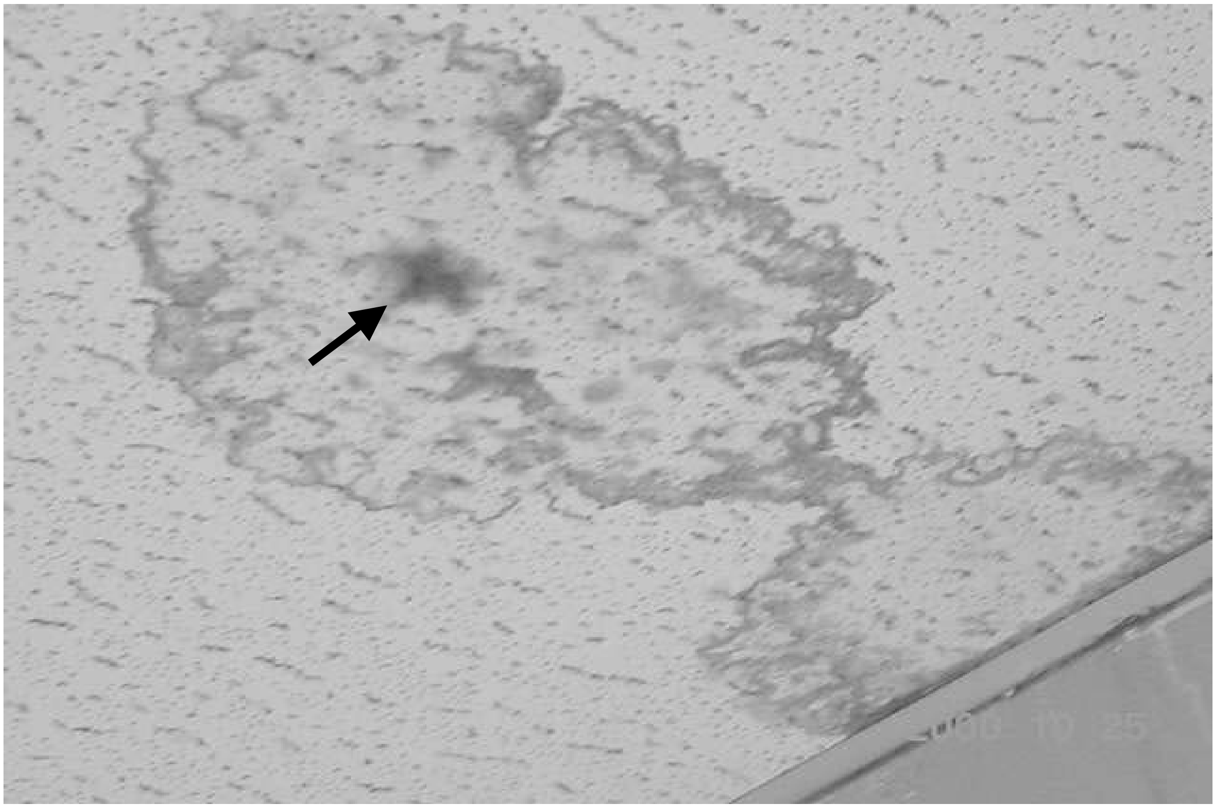
Thermostat Controlling HVAC Unit for Modular Classroom

Picture 9



Water Damaged Wall Plaster (Efflorescence)

Picture 10



Water Stained Ceiling Tile: Dark Spot Indicates Possible Mold Growth

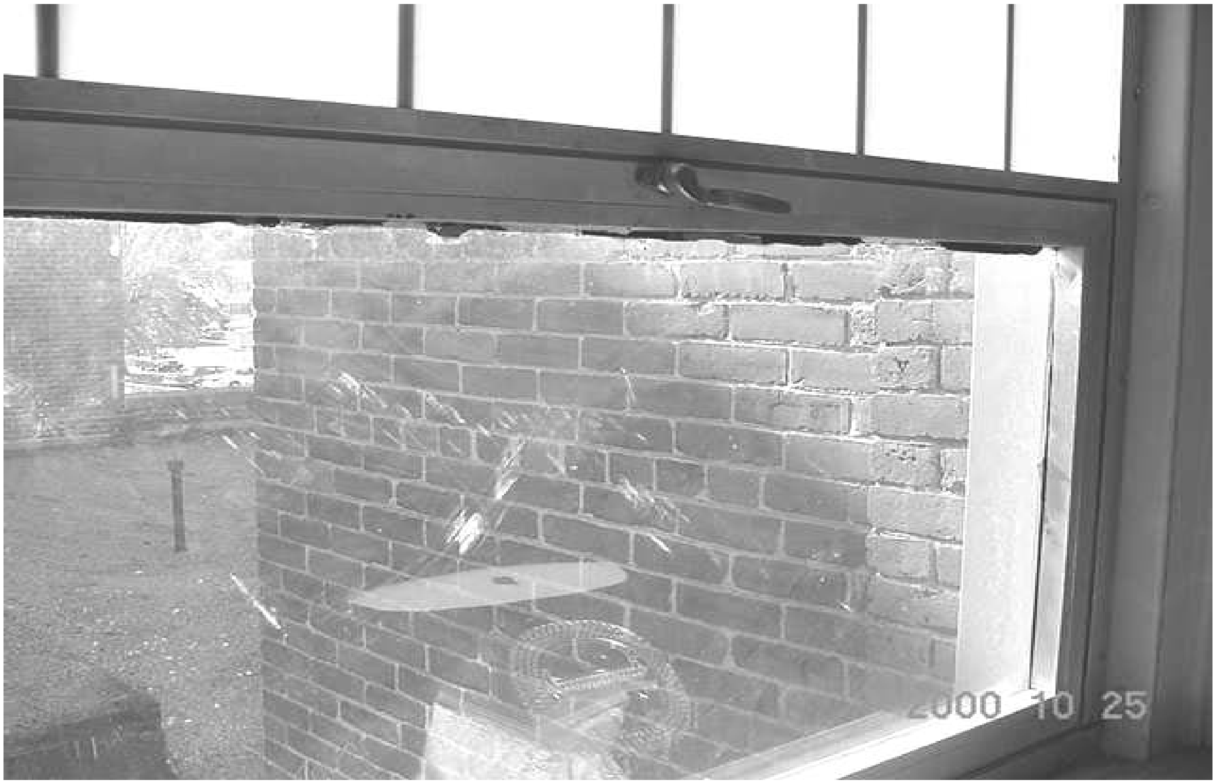
Picture 11

Sealant Compound above Stained Ceiling Tiles in Previous Picture (1968 Addition)

Picture 12

Water Pooling on Roof Near Univent Fresh Air Intake

Picture 13

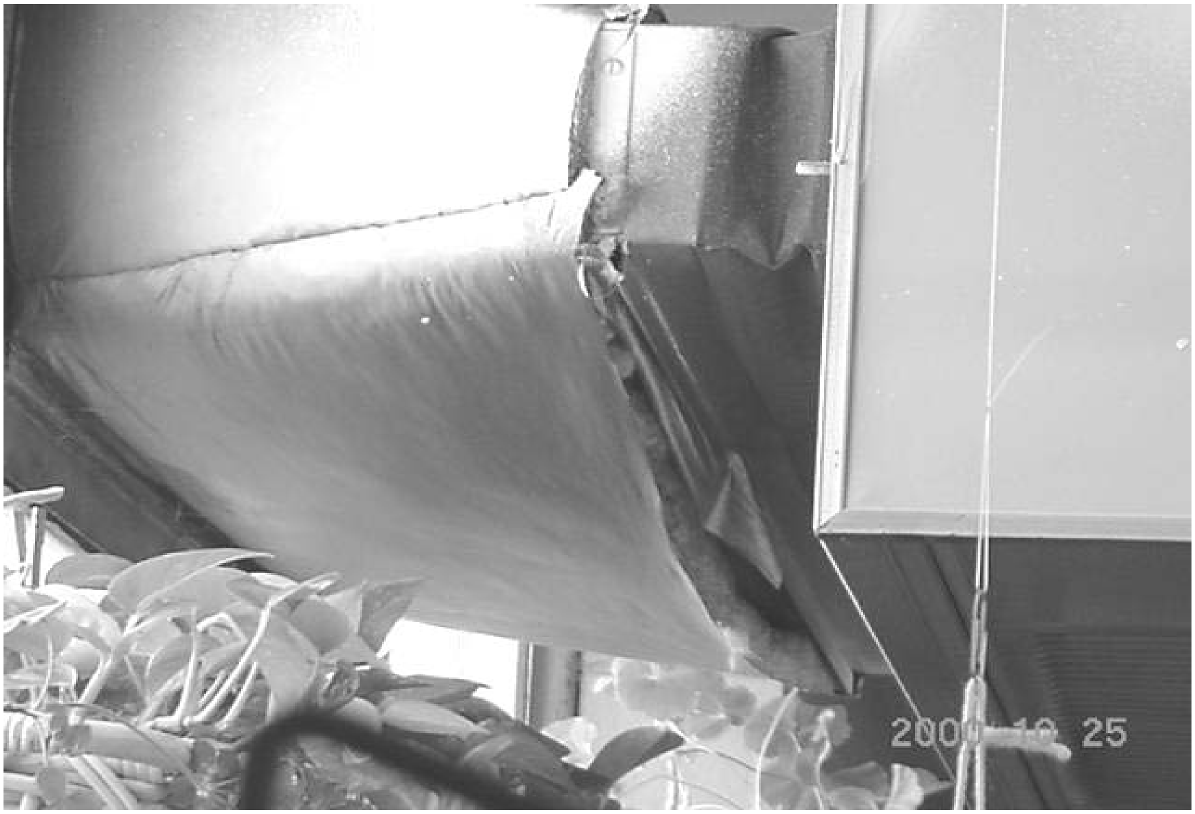


Crumbling/Damaged Window Caulking

Picture 14

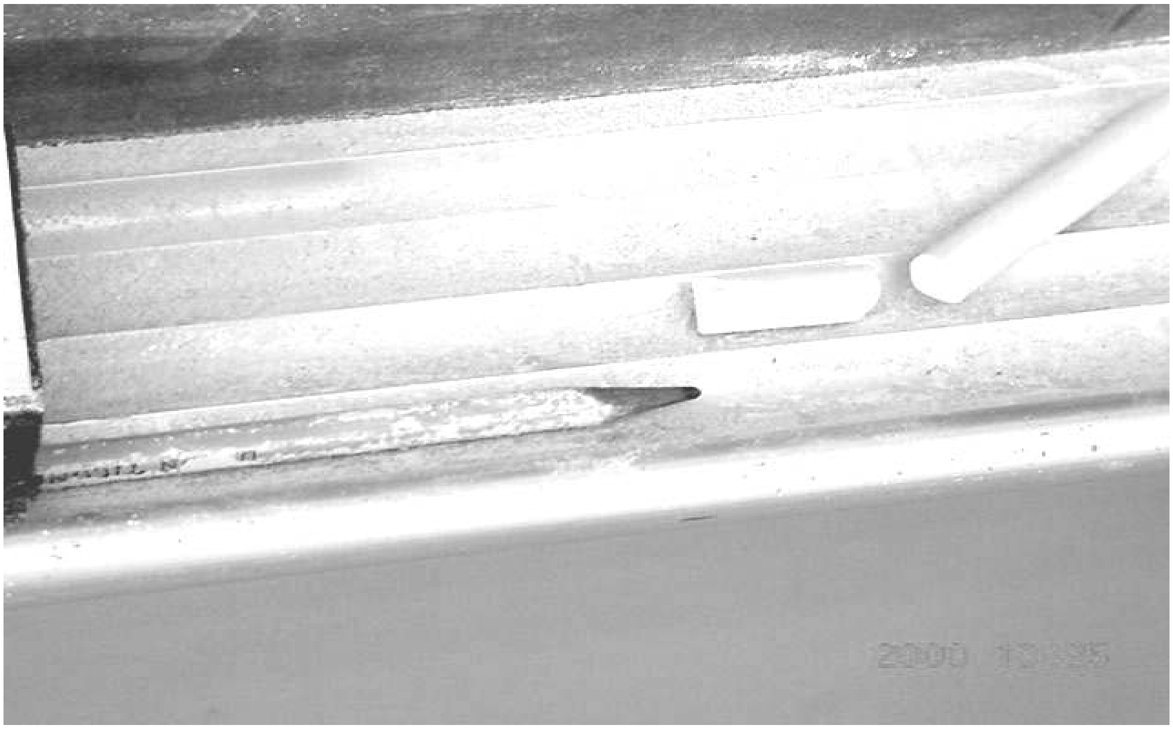
Open Boiler Room Door

Picture 15



Exposed Fiberglass Insulation around Univent Ductwork

Picture 16



Accumulated Chalk Dust

Picture 17

Accumulated Items in Classroom

Picture 18

Spray Can of Insecticide: Note Bubbling at the Bottom of Spray Can

Picture 19

Floor Drain in Boy's Restroom, Across from the Main Office

Picture 20

Passive Bathroom Vent Sealed with Plywood

Picture 21

Hole in Side of Annex Building Occupied by Birds: Note Bird Waste on Side of Building

TABLE 1

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	469	60	50					Weather conditions: clear, sunny
Boiler Room Custodian Office	505	70	36	2	No	Yes	No	Door open, 2 oil-fired boilers, respiratory complaints/health concerns
209	601	74	32	19	Yes	Yes	Yes	Window and door open, cleaning product under sink, chalk dust, dry erase board/cleaner, accumulated items (boxes) above coat closet
208	1023	73	34	21	Yes	Yes	Yes	Paper/items on univent, exhaust vent blocked by computer cart, door open
210	930	76	31	22	Yes	Yes	Yes	Univent and exhaust vent blocked, water damaged ceiling plaster
Custodial Closet					No	Yes	Yes	Passive vents
215	894	75	30	24	Yes	Yes	Yes	25 computers, no a/c, heat complaints, exhaust vent blocked, door open
Restrooms					Yes	Yes	Yes	Passive vent for boy's restroom sealed

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
211	887	77	29	20	Yes	Yes	Yes	Window open, items on univent, pencil shavings on windowsill, exhaust vent blocked by tables
212	797	77	30	20	Yes	Yes	Yes	Window and door open, exhaust vent blocked by table, cleaning product on counter
214	704	74	30	1	Yes	Yes	Yes	Window and door open, water damaged wall plaster, efflorescence, chalk dust
206	978	73	37	0	Yes	Yes	Yes	Cleaning product under sink-bleach, spray cleaner on desk, door open, water damaged wall plaster around window, univent off-return blocked by boxes
106	1675	75	34	0	Yes	Yes	Yes	Missing/damaged caulking around windows, univent return blocked, door open
108	1536	75	37	24	Yes	Yes	Yes	Exhaust vent blocked by box, pooling water on roof near univent air intake
109	911	77	33	25	Yes	Yes	Yes	Window and door open, items on univent, 1 plant

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TABLE 3

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
110	787	77	27	25	Yes	Yes	Yes	Window open, exhaust blocked by computer table
115	1135	77	32	26	Yes	Yes	Yes	Exhaust vent blocked by chair
111	700	77	29	20	Yes	Yes	Yes	Window and door open, exhaust vent blocked by open door
112	678	77	31	1	Yes	Yes	Yes	Univent return blocked by table/storage boxes, exhaust vent blocked by computer table, door open
114	1245	76	35	21	Yes	Yes	Yes	Water damaged ceiling plaster, door open
35	697	76	30	23	Yes	Yes	Yes	Window open, water damaged ceiling plaster, univent return blocked by bookcase
35 Restroom					No	Yes	Yes	Combination supply/exhaust over "P"
28	640	71	32	2	Yes	Yes	Yes	Exhaust vent blocked by bookcase
Auditorium	518	68	36	0	No	Yes	Yes	Exhaust vents under stage-partially blocked by mats, exposed fiberglass insulation-back stage

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TABLE 4

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								area
Hallway								Boiler room odors in hall way
Main Office	886	73	34	1	No	No	No	Respiratory complaints, photocopier
1st Floor Women's Restroom					No	Yes	Yes	Complaints of dust accumulation
5	1131	72	35	2	Yes	Yes	Yes	Window and door open, exhaust off, 5 CT-possible mold growth, 3 plants
3	1400	73	39	23	Yes	Yes	Yes	Window and door open, 6 CT, vents blocked by items
Hallway (outside rooms 3 & 5)								12 CT-possible mold growth
Boy's 2nd floor restroom							Yes	
2	1584	74	36	21	Yes	Yes	Yes	Window and door open, 4 CT, items on univent
1	2000+	74	37	21	Yes	Yes	Yes	Univent and exhaust off, chalk dust

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Comfort Guidelines

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TABLE 5

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
4	2000+	74	36	23	Yes	Yes	Yes	Water damaged window frame, spaces around window, cardboard materials on window
8	2000+	73	37	21	Yes	Yes	Yes	Univent and exhaust off, exposed fiberglass insulation-univent duct, door open
6 Music Room		72	35	0	Yes	Yes	Yes	Univent/exhaust blocked by boxes
10	1900	74	34	0	Yes	Yes	Yes	Univent and exhaust off, exhaust vent blocked
7	1034	73	34	2	Yes	Yes	Yes	Univent blocked by items, exhaust vent off, photocopier
9	699	72	31	0	Yes	Yes	Yes	Exhaust vent partially blocked
10	1809	74	36	23	Yes	Yes	Yes	
Library	609	73	32	0	Yes	No	No	Fly jinx**
Basement floor								Damaged pipe insulation, gas stove-no exhaust vent, hole in south exterior wall-birds

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Temperature -	70 - 78 °F
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TABLE 6

Indoor Air Test Results –Charles W. Morey Elementary School, Lowell, MA – October 25, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Bottom Floor-'68 Addition								Damaged fiberglass pipe insulation
Portable Room 12	2000+	75	40	22	Yes	Yes	Yes	Thermostat controls-"off/auto"
Portable Room 11	2000+	77	44	13	Yes	Yes	Yes	

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